MANUFACTURING METHOD OF FERRULE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a manufacturing method of a ferrule used as a connector of an optical fiber. More particularly, the present invention relates to a manufacturing method of a ferrule into which a plurality of optical fibers can be inserted, a manufacturing method of a ferrule, two of which are accurately connectable to each other, and a manufacturing method of a ferrule which is accurately made of an electroformed element to which metal is deposited and electroformed.

2. Description of the Related Art

Referring to Fig. 7B, an optical fiber connector generally includes two tubular members (hereinafter referred to as ferrules) 11a and 11b for accurately holding two optical fibers 32a and 32b of 0.13 mm in diameter in predetermined positions and securing them coaxially, and an alignment part 33 for holding these ferrules 11a and 11b in an opposite direction so as to abut against each other. The ferrule 11 is in the shape of a cylinder, as shown in Fig. 7A, for example. At the center of the cylinder of approximately 8 mm in length, there is a perfect circular through hole 12 of 0.126 mm in diameter formed along a longitudinal direction.

Previously, Japanese Republication No. 00/031574 disclosed a manufacturing method of the ferrule 11. The prior method will be hereinafter described.

An electroforming device 10 shown in Fig. 8 includes an electroforming bath 26, an electroforming fluid 13 poured in the electroforming bath 26, and a positive electrode 14 and a

negative electrode 18 disposed inside the electroforming bath 26. Four positive electrodes 14 are provided on a base 34 which is disposed in the bottom of the electroforming bath 26 in such a manner as to surround an electrode line 19 connected to the negative electrode 18.

The negative electrode 18 provided on a support jig 15, as described later, is electrically connected to the electrode line 19 stretched between the upper and lower ends of the support jig 15. On the base 34, air nozzles 16 act as agitators and are provided at intervals of 90 degrees in the circumferential direction of the electrode line 19.

The electroforming fluid 13 is selected depending on the material of electroformed metal accreted to the periphery of the electrode line 19.

The positive electrode 14 is properly chosen from nickel, iron, copper, cobalt and the like in a plate shape or a spherical shape, in accordance with the type of metal to be electroformed. When using the spherical shaped electrode, for example, the electrode is put in a basket made of titanium and covered with a polyester cloth bag.

The air nozzle 16 blows a little amount of air from a hole formed therein in order to agitate the electroforming fluid 13. However, a way to agitate the electroforming fluid 13 is not limited to this, and it is possible to use a propeller, ultrasound, ultravibration, and the like.

Examples of the electrode line 19 include a metal line of iron and alloys thereof, aluminum and alloys thereof, or copper and alloys thereof; a metal line of one of these metals with thin solder plating; and a plastic line such as a nylon line, a polyester line, and a polytetrafluoroethylene line. The proper electrode line 19 is chosen and used. When using a plastic line, it is necessary to apply an electroless plating of nickel, silver, or the like to the surface thereof for the purpose of giving electrical conductivity. Since the internal diameter of the ferrule 11 is decided depending on the type of electrode line 19, it is required for the electrode line 19 to have an accurate thickness, a

high degree of perfect roundness, and a high degree of straightness. It is possible to adjust the thickness, the degree of roundness, and the degree of straightness of the electrode line 19 by means of extrusion by a die, stretching the line, a center less process and the like. At this point in time, in a case of a stainless steel line of 125 μm in diameter, for example, it is possible to obtain a stainless steel line product, the diameter of which may vary in a range of approximately ±0.5 μm.

The structure of the support jig 15a will be hereinafter described in detail referring to Figs. 9A and 9B. Fig. 9A is a side view of the support jig 15a, and Fig. 9B is a bottom view thereof taken from line 9B-9B of a bottom plate 21. In the support jig 15a, a top plate 20 and the bottom plate 21 are coupled via four columns 22. The top plate 20 and the bottom plate 21 are made of an electrical insulating material such as polyvinyl chloride resin, polyamide resin, polyacetal resin, and polyethylene resin. The columns 22 are made of metal or plastic such as stainless steel and titanium. The top plate 20 and the bottom plate 21 are secured to the columns 22 with screws. At the center of the top plate 20, a stainless steel screw 23a serving as the negative electrode 18 is provided to penetrate the top plate 20. The stainless steel screw 23a secures one end 17a of a stainless steel spring 17 on the bottom surface of the top plate 20. At the center of the bottom plate 21, as in the case of the top plate 20, a stainless steel screw 23b is provided to penetrate the bottom plate 21 and project into the top surface of the bottom plate 21. A plastic clip 25 is secured to the screw 23b. As described above, there are four round holes 24 bored in the bottom plate 21. The air nozzles 16 pass through the round holes 24. The other end 17b of the stainless steel spring 17 pulls one end of the electrode line 19, and the clip 25 pinches the other end of the electrode line 19, while the electrode line 19 and the spring 17 are stretched. Since the electrode line 19 is attached to the support jig 15a in this manner, the electrode line 19 is held inside the electroforming bath 26 in such a manner as to stretch straight in a perpendicular direction.

The support jig 15a shown in Figs. 9A and 9B is used for electroforming a single-core type ferrule 11. In electroforming a double-core type ferrule 11, for example, a support jig 15b shown in Fig. 10 can be used. Referring to Fig. 10, the support jig 15b has two plastic auxiliary members 27 disposed between the top plate 20 and the bottom plate 21. A plastic line hold member 28 with two narrow holes 29 is embedded at the center of the auxiliary member 27. Two stainless steel screws 23 and two clips 25 are provided on each of the top plate 20 and the bottom plate 21. Solder joints 45 for integrating the electrode lines 19 are disposed at a position a predetermined distance away from the auxiliary member 27, for the purpose of keeping the two electrode lines 19 in parallel and keeping a predetermined distance from each other. Except for the structure described above, the support jig 15b has the same structure as the support jig 15a shown in Figs. 9A and 9B.

When electroforming a triple-core type ferrule or a multiple-core type ferrule having more than three cores, as in a case of the support jig 15b shown in Fig. 10, the line hold member 28 of the support jig is changed so that the number of the stainless steel screws 23 and the clips 25 are increased in accordance with the number of lines. In addition, an elastic member such as a rubber member, for example, may be used instead of the spring 17 to stretch and hold the electrode line 19, and a weight may be attached to the lower end of the electrode line 19.

In the configuration described above, the operation of electroforming the ferrule 11 with the use of the electroforming device 10 will be hereinafter described.

After pouring the electroforming fluid 13 in the electroforming bath 26, a DC voltage is applied between the positive electrode 14 and the negative electrode 18 so that the current density thereof becomes approximately 4 to 20 A/dm^2. The electroforming with this current density grows electrodeposits 30 of 3 mm in diameter around the electrode line 19 in almost one day. After the

electroforming, the support jig 15 is taken out of the electroforming bath 26, and the electrode line 19 is taken out of the support jig 15. There are several ways to take out the electrode line 19 from the electrodeposits 30, such as by pulling out the electrode line 19, by pushing out the electrode line 19, and by dissolving the electrode line 19 by heated acid or alkaline solution. An obtained electroformed element is cut into a predetermined length with a slice cutter, for example, in order to be used as the ferrule 11. Especially, the internal diameter of the ferrule 11 manufactured with this method has extremely high accuracy, and the accuracy of the ferrule 11 depends on the dimensional accuracy of the electrode line 19 described above. It is preferable that the outer periphery of the ferrule 11 is subjected to a finish machining, for the purpose of increasing the degree of perfect roundness of the outside diameter thereof. In the finish machining, the outer periphery of the ferrule 11 may be cut by an NC machine.

Recently, the need for a multiple-core type ferrule 11 having two or more cores has grown in addition to the need for a single-core type ferrule 11. It is necessary to develop multiple-core type ferrules 11 which can be connected to each other with high accuracy.

In Japanese Republication No. 00/031574 described above, the multiple-core type ferrule is formed in such a way that electrode lines 19, the number of which is equal to the number of cores, are disposed as the negative electrodes, and the electrodeposits 30 are deposited to all of the electrode lines 19. Thus, the electrodeposits 30 are deposited concentrically with respect to each of the electrode lines 19. As a result, the outside shape of the electroformed element is not perfectly round, so that the periphery thereof has to be cut into a circle or a rectangle in cross section with the finish machining. In the finish machining, the electroformed element is positioned with reference to a line of the through holes 12, but the through holes 12 cannot be touched due to the

prevention of a scratch. Accordingly, a non-contact virtual line has to be used as a reference line, so that there is a problem that it is difficult to accurately position the electroformed element.

Figs. 11A, 11B and 11C show the states of the electrodeposits 30 during the process of manufacturing the multiple-core type ferrule 11 according to the prior art.

Fig. 11A shows the state of the electrodeposits 30 on the electrode lines 19 during the process of manufacturing the double-core type ferrule 11. Fig. 11B shows the state of the electrodeposits 30 on the electrode lines 19 during the process of manufacturing the triple-core type ferrule 11. Fig. 11C shows the state of the electrodeposits 30 on the electrode lines 19 during the process of manufacturing the quadruple-core type ferrule 11. For the double-core type ferrule 11, in which the two electrode lines 19 are disposed linearly, as shown in Fig. 11A, a recess is formed between two lumps of electrodeposits 30, when the electrodeposits 30 are concentrically deposited with the passage of time. For the triple-core or quadruple-core type ferrule, in which the three or four cores are disposed as shown in Figs. 11B and 11C, the electroforming fluid 13 does not reach a center portion, when the electrodeposits 30 are deposited to a certain degree. As a result, a gap 31 is left at the center portion, so that the strength of the center portion tends to decrease.

SUMMARY OF THE INVENTION

In view of the above-mentioned problems, an object of the present invention is to provide a manufacturing method of a multiple-core type ferrule by means of electroforming, a position of which is precisely fixed in machining an outside shape thereof, and also a manufacturing method of a multiple-core type ferrule a center portion of which has sufficient strength.

According to an aspect of the present invention, a method for manufacturing a ferrule includes the steps of: immersing a negative electrode line and a positive electrode in an

electroforming fluid in an electroforming bath; depositing metal on the negative electrode line by electroforming to form a cylindrical electroformed element, thereby making the ferrule made of the electroformed element. When electroforming the electroformed element, at least one dummy line is disposed in the vicinity of the negative electrode line, and the electroformed element is formed so that the negative electrode line and the dummy line are integrally embedded therein. Then, at least the dummy line is taken out of the electroformed element, for the purpose of forming a through hole into which an optical fiber is inserted.

According to this manufacturing method, electrodeposits are grown concentrically with respect to the electrode line. Then, a core portion is integrally covered with the electroformed element, since at least one dummy line is disposed in the vicinity of the electrode line. Thus, it is possible to manufacture the multiple-core type ferrule in a perfectly round shape by means of taking out at least the dummy line.

According to this aspect of the invention, at least one dummy line is disposed in the vicinity of the negative electrode line during electroforming. The electroformed element is formed so that the negative electrode line and the dummy line are integrally embedded therein, and at least the dummy line is taken out from the electroformed element in order to form the through hole into which the optical fiber is inserted. Because electrodeposits are concentrically deposited on the electrode line, all of the lines, including the dummy line disposed in the vicinity of the electrode line, are covered with the electrodeposits. Therefore, it is possible to obtain a multiple-core type ferrule of a perfectly round shape.

In the prior art, a gap is left at the center portion of the electroformed element, since the electrodeposits are deposited from various directions. When there is a single electrode line carrying current as in the present invention, however, the gap is not left and it is possible to obtain

the electroformed element with stable strength. Also, because the dummy line does not carry the current, it is possible to make the dummy line out of a certain material, or to subject the dummy line to a certain treatment, for the purpose of making it easy to be taken out after the electroforming, by means of pulling out, pushing out, or dissolving.

According to another aspect of the present invention, at least one dummy line is disposed in the vicinity of the negative electrode line, and at least one positioning line is disposed in the vicinity of the dummy line during electroforming. An electroformed element is formed so that the negative electrode line, the dummy line, and the positioning line are integrally embedded therein. Then, out of the electrode line and the dummy line, at least the dummy line is taken out from the electroformed element in order to form the through hole into which an optical fiber is inserted. The positioning line is also taken out from the electroformed element in order to form the positioning hole which is used when the ferrule is fitted to another ferrule. Accordingly, it is possible to accurately position the ferrules when the same multiple-core type ferrules are connected to each other. The more cores the ferrule has, the higher positioning accuracy is required. The positioning line for fit especially makes it easy to carry out the positioning for connection.

According to another aspect of the invention, a positioning hole, which is formed only by taking out a positioning line, is usable as a positioning hole of a socket into which a plug pin of another ferrule is inserted for fit.

According to another aspect of the invention, the plug is provided only by taking out the positioning line from the electroformed element and fixedly attaching the plug pin therein. The plug is inserted into the positioning hole of another ferrule when the ferrules are fitted to each other.

According to another aspect of the invention, at least one dummy line is disposed in the vicinity of the negative electrode line, and at least one positioning line is disposed in the vicinity of the dummy line during electroforming. The electroformed element is formed so that the negative electrode line, the dummy line, and the positioning line are integrally embedded therein. Then, out of the electrode line and the dummy line, at least the dummy line is taken out from the electroformed element in order to form a through hole into which an optical fiber is inserted. The positioning line is also taken out from the electroformed element in order to form a positioning hole which is used for positioning in machining the outside shape of the electroformed element. Accordingly, it is possible to accurately carry out the outside machining and other machining with reference to the positioning hole. As a result, the optical fibers are accurately positioned and connected.

According to another aspect of the invention, the line to be taken out from the electroformed element is subjected to the insulation treatment. Thus, it is easy to take out the dummy lines from the electroformed element by means of pulling out or pushing out the dummy lines, and the diameter of the hole becomes accurate.

According to another aspect of the invention, the line to be taken out from the electroformed element is made of an electrical insulating material, it is possible to manufacture the multiple-core type ferrule without subjecting the lines to the insulation treatment, an oxide film and a fluorine coating, or the like, for the purpose of preventing electrical connection to the electrode line.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other features of the present invention will be more readily apparent from the following detailed description and drawings of the illustrative embodiments of the invention wherein like reference numbers refer to similar elements throughout the views and in which:

Fig. 1A is a sectional view of an electrode line and dummy lines which are fixedly disposed in an electroforming bath, according to an embodiment of a manufacturing method of a ferrule of the present invention;

Figs. 1B to 1E are sectional views of the electrode line and dummy lines showing the processes of growth of electrodeposits, according to the embodiment of the present invention shown in Fig. 1A;

Fig. 1F is a sectional view of a complete triple-core type ferrule, according to the embodiment of the present invention shown in Fig. 1A;

Fig. 2A is a sectional view of an electrode line, dummy lines, and positioning lines for fit which are fixedly disposed in an electroforming bath, according to another embodiment of a manufacturing method of a ferrule of the present invention;

Figs. 2B to 2E are sectional views of the electrode line, the dummy lines, and the positioning lines showing the processes of growth of electrodeposits, according to the embodiment of the present invention shown in Fig. 2A;

Fig. 2F is a sectional view of a complete quintuple-core type ferrule, according to the embodiment of the present invention shown in Fig. 2A;

Fig. 3 is a front view of an electroforming device used in an embodiment of a manufacturing method of a ferrule according to the present invention;

Fig. 4A is a sectional view of an electrode line, dummy lines, and positioning lines for machining which are fixedly disposed in an electroforming bath, according to another embodiment of a manufacturing method of a ferrule of the present invention;

Fig. 4B is a sectional view of an electroformed element after the growth of electrodeposits, according to the embodiment of the present invention shown in Fig. 4A;

Fig. 4C is a sectional view of a complete quintuple-core type ferrule after outside machining, according to the embodiment of the present invention shown in Fig. 4A;

Fig. 5A is a sectional view of an electrode line, dummy lines, positioning lines for fit, and positioning lines for machining which are fixedly disposed in an electroforming bath, according to another embodiment of a manufacturing method of a ferrule of the present invention;

Fig. 5B is a sectional view of an electroformed element after the growth of electrodeposits, according to the embodiment of the present invention shown in Fig. 5A;

Fig. 5C being a sectional view of a complete quintuple-core type ferrule after outside machining, according to the embodiment of the present invention shown in Fig. 5A;

Fig. 6A is a sectional view of a quadruple-core type ferrule in which an electrode line remains;

Fig. 6B is a sectional view of a pair of ferrules, in one of which positioning holes formed after taking out positioning lines for fit are used as a sockets, and in the other of which fitting pins fixedly attached to the positioning holes are used as a plug;

Fig. 6C is a sectional view of a pair of ferrules, in one of which positioning holes formed after taking out positioning lines for fit are used as a socket, and in the other of which fitting pins integrally provided in a housing are used as a plug;

Fig. 6D is a perspective view of a pair of ferrules, in one of which positioning notches formed after taking out positioning lines for machining are used as fitting depressions of a socket, and in the other of which projections integrally formed in a housing are used as a plug;

Fig. 7A are sectional views of a conventional single-core type ferrule along a longitudinal direction and along a radial direction;

Fig. 7B is a sectional view of the ferrule shown in Fig. 7A along the longitudinal direction;

Fig. 8 is an explanatory view of a conventional electroforming device;

Fig. 9A is a front view of a support jig of the conventional electroforming device;

Fig. 9B is a bottom view thereof;

Fig. 10 is a front view of another support jig of the conventional electroforming device;

Fig. 11A is a sectional view of a double-core type ferrule during the growth of the electrodeposits by using the conventional electroforming device;

Fig. 11B is a sectional view of a triple-core type ferrule during the growth of the electrodeposits by using the conventional electroforming device; and

Fig. 11C is a sectional view of a quadruple type ferrule during the growth of the electrodeposits by using the conventional electroforming device.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

An embodiment of the present invention will be hereinafter described.

In the present invention, at least one electrode line carrying current as an electrode and at least one insulating dummy line arranged in the vicinity of the electrode line are immersed in an electroforming fluid to deposit and grow electrodeposits on the periphery of the electrode line by electroforming. Carrying on the growth of the electrodeposits forms an electroformed element in a

cylindrical shape which contains the dummy line. Then, at least the dummy line is pulled out of the electroformed element to form a through hole. In this way, a ferrule to which an optical fiber is inserted is manufactured.

If a plurality of dummy lines are used, the multiple-core type ferrule is formed. The electrode line may be pulled out of the electroformed element to form another through hole into which the optical fiber is inserted, or the electrode line may not be pulled out of the electroformed element.

In addition to the dummy line which forms the through hole for the insertion of the optical fiber, an insulating line with a larger diameter than that of the dummy line (namely, the optical fiber to be inserted) may be disposed to form a positioning hole for fitting or for machining. The positioning hole is also used as a socket hole into which a positioning projection of a plug is inserted, or as a reference hole for positioning in machining the electroformed element.

The shape of the reference hole for positioning in machining the electroformed element is not limited to being round. The reference hole may be a triangle, another type of polygon, an ellipse, a half-circle, and the like. In a case of a polygonal shaped hole, it can be used as a positioning lock of the plug.

EXAMPLE

An electroforming device 10 used in a manufacturing method of a ferrule according to the present invention is basically identical to that shown in Fig. 8. In this invention, however, a conductive electrode line and an insulating dummy line are disposed together in electroforming fluid to manufacture a multiple-core type ferrule.

The manufacturing method will be hereinafter described in detail while referring to Fig. 3.

In a support jig 35, a top plate 20 and a bottom plate 21, which are made of an electrical insulating material, are coupled to each other via four metal or plastic columns 22 with screws. Two auxiliary members 27 are disposed at an upper portion and a lower portion between the top plate 20 and the bottom plate 21. A line hold member 28 is embedded at the center of each auxiliary member 27. Three narrow holes 29 are bored at the central portion of the line hold member 28.

A center screw 23a penetrates the center of the top plate 20, and the lower end thereof projects from the bottom surface of the top plate 20. Plural screws 37a are provided around the screw 23a so as to penetrate the top plate 20, and the lower ends thereof project from the bottom surface of the top plate 20. The center screw 23a and the screws 37a are electrically insulated from each other. One end 17a of a spring 17 is secured to the lower end of the center screw 23a. The upper end of the center screw 23a is connected to a negative source as a negative electrode 18.

One end 17a of the other springs 17 are secured to the lower ends of the plural screws 37a.

A center screw 23b penetrates the center of the bottom plate 21, and the upper end thereof projects from the top surface of the bottom plate 21. Plural screws 37b are provided around the screw 23b so as to penetrate the bottom plate 21, and the upper ends thereof project from the top surface of the bottom plate 20. The center screw 23b and the screws 37b are electrically insulated from each other. A clip 25 is secured to each upper end of the center screw 23b and the peripheral screws 37b. Four round holes 24 for fitting air nozzles 16 are bored in the bottom plate 21.

The upper end of the electrode line 19 is hooked on the lower end of the center spring 17, and the center clip 25 pinches the lower end of the electrode line 19 while stretching the spring 17. The upper ends of the dummy lines 36 are hooked on the lower ends of the other springs 17, and the other clips 25 pinch the lower ends of the dummy lines 36 while stretching the springs 17.

Herein, examples of the dummy lines 36 includes a metal line such as iron and alloys thereof, aluminum and alloys thereof, copper and alloys thereof, a plastic line such as nylon lines, polyester lines, polytetrafluoroethylene lines. The proper dummy line 36 is chosen and used. When the dummy line 36 is made of metal, it is preferable to provide an insulating film like a fluorine coating and an oxide film therearound, for the purpose of providing electrical insulation in the dummy line 36. Also, the insulating film makes it easy to pull out the dummy line 36 from the electroformed element after the electroforming. However, it is more preferable that the dummy line 36 is made of an insulating material so as to be electrically unaffected by the electrode line 19.

In this way, the present invention is characterized in that the dummy lines 36 are provided in the vicinity of and in parallel with the electrode line 19, which carries current as the negative electrode.

EMBODIMENT OF FIGS. 1A TO 1F:

Figs. 1A to 1F show the manufacturing processes of the ferrule 11 in which three cores are aligned in a line.

Fig. 1A: The electrode line 19 is fixed in the support jig 35. The dummy lines 36 are also fixed on both sides of the electrode line 19 at predetermined intervals in the support jig 35. The diameters of the electrode line 19 and the dummy lines 36 are the same as that of an optical fiber 32 to be inserted therein.

Fig. 1B: Upon starting the electroforming using the electroforming device 10, the electrodeposits 30 are gradually deposited on the electrode line 19 in a concentric manner.

Fig. 1C: As the growth of the electrodeposits 30 advances, the dummy lines 36 are gradually covered with the electrodeposits 30.

Fig. 1D: When the electrodeposits 30 are further deposited, the dummy lines 36 are completely covered. The electrodeposits 30 are always deposited concentrically with respect to the electrode line 19, because there is only a single electrode line 19 which carries current.

Fig. 1E: The electroforming is continued until the electroformed element grows to a predetermined thickness, and then is finished.

Fig. 1F: After finishing the electroforming, all of the electrode line 19 and dummy lines 36 are taken out by a known means such as pulling out, pushing out, or dissolving. Then, a triple-core type ferrule 11 with three through holes 12 is formed.

According to the prior art, when the multiple-core type ferrule 11 is manufactured, all of the plural electrode lines 19 disposed in parallel carry the current during the electroforming. Thus, the completed electroformed element is not a perfect round in cross section, so that it is necessary to cut the electroformed element into the perfect round or other shapes after the electroforming. It is inefficient and difficult to cut the electroformed element into the predetermined shape.

In the multiple-core type ferrule 11 according to the preset invention, however, the electroformed element becomes almost perfectly round in shape, because there is only one conductive electrode line 19 and the insulating dummy lines 36 are disposed in the vicinity thereof. As a result, when the electroformed element is used as the round ferrule 11, the finish machining is almost unnecessary or extremely easy. In the prior art, a gap 31 is left at a center portion of the electroformed element (see Fig. 11B or 11C), since the electrodeposits 30 are deposited from various directions. In the present invention, however, the gap 31 does not appear because there is only one conductive electrode line 19, so that it is possible to obtain the electroformed element with stable strength. Since the dummy lines 36 are insulated, it is possible to make the dummy lines 36 out of material which is easy to be taken out from the electroformed element by means of

pulling out, pushing out, dissolving or the like after electroforming the electroformed element. It is also possible to subject the dummy lines 36 to a certain treatment in advance for the purpose of making it easy to be taken out.

In the embodiment of Figs. 1A to 1F, the two dummy lines 36 are disposed on the both sides of the electrode line 19 to form a three-core type ferrule 11 with the three holes aligned in line, but the present invention is not limited thereto. The ferrule 11 with two cores may be formed, for example, by means of pulling out the two dummy lines 36 and not pulling out the electrode line 19 in Fig. 1E. The two or more dummy lines 36 may be disposed on one side or both sides of the electrode line 19. The three or more dummy lines 36 may be disposed around the electrode line 19 to form the concentric multiple-core type ferrule 11. The dummy lines 36 may be disposed in vertical or horizontal two or more lines. The optical fibers different in thickness may be mixed in the ferrule 11.

EMBODIMENT OF FIGS. 2A TO 2F:

In the embodiment of Figs. 1A to 1F, the dummy lines 36 of the same diameter as the electrode line 19 are disposed in the vicinity of the conductive electrode line 19 to form the multiple-core type ferrule 11, but the present invention is not limited thereto. For example, it is possible to dispose lines which have different diameters from the electrode line 19, for the purpose of forming holes for fitting.

Fig. 2A: Dummy lines 36 (four dummy lines, in this embodiment) are disposed around an electrode line 19. The diameters of the electrode line 19 and the dummy lines 36 are the same as that of an optical fiber 32 to be inserted therein. In the embodiment of Figs. 2A to 2F, positioning lines 38 for fit are disposed outside of the dummy lines 36 symmetrically with respect to the center

of the electrode line 19. The positioning line 38 has a larger diameter than the electrode line 19 and the dummy lines 36. The positioning lines 38 for fit are insulated as with the dummy lines 36, and are made of similar material to that of the dummy lines 36.

Fig. 2B: Upon starting electroforming with an electroforming device 10, electrodeposits 30 are gradually deposited to the electrode line 19 in a concentric manner.

Fig. 2C: As the growth of the electrodeposits 30 advances, the dummy lines 36 are gradually covered with the electrodeposits 30.

Fig. 2D: When the electrodeposits 30 are further deposited, the dummy lines 36 are completely covered, and the positioning lines 38 for fit are gradually covered with the electrodeposits 30.

Fig. 2E: The positioning lines 38 for fit are completely covered, too. The electroforming is continued until the electroformed element grows to a predetermined thickness, and then is finished.

Fig. 2F: All of the conductive electrode line 19, the insulating dummy lines 36, and the insulating positioning lines 38 are taken out of the electroformed element by means of pulling out, pushing out, dissolving or the like. Then, the ferrule 11 with five through holes 12 and fitting holes 40 is formed.

The fitting holes 40 formed with the above method are used for coupling the ferrules 11 in which the optical fibers 32 are inserted as shown in Figs. 6B or 6C. In Fig. 6B, nothing is inserted into the two fitting holes 40 of one ferrule 11a in order to use the ferrule 11a as a socket. Fitting pins 42 are inserted into the two fitting holes 40 of the other ferrule 11b in such a manner that the parts of the fitting pins 42 project therefrom to use the ferrule 11b as a plug. Consequently, it is possible to connect the two ferrules 11a and 11b to each other in an accurate position.

In Fig. 6C, nothing is inserted into the two fitting holes 40 of one ferrule 11a in order to use the ferrule 11a as the socket. The other ferrule 11b, which has the fitting pins 42 formed integrally with a housing by another way, is used as the plug. Accordingly, it is possible to accurately connect the two ferrules 11a and 11b to each other.

The more cores the ferrule 11 has, the higher positioning accuracy is required. Disposing the positioning lines 38 for fit, however, makes it easy to adjust the positioning of coupling.

EMBODIMENT OF FIGS. 4A TO 4C:

In the embodiments of Figs. 1A to 1F and Figs. 2A to 2F, the electroformed element of the perfect round in cross section formed by the electroforming device 10 is used as the ferrule 11 without machining. There is a case, however, in which the electroformed element has to be cut into another shape in accordance with a product. Accordingly, in the embodiment of Figs. 4A to 4C, triangle positioning lines 39 for machining are disposed outside of the dummy lines 36, in order to accurately carry out the machining of the outside shape of the electroformed element with reference to the positioning lines 39.

Fig. 4A: Two dummy lines 36 are linearly aligned on each side of an electrode line 19. On both sides of the dummy lines 36, triangular positioning lines 39 for machining are disposed symmetrically with respect to the electrode line 19. The positioning lines 39 for machining, which are made of the similar material to the dummy lines 36, do not carry current as with the dummy lines 36.

Fig. 4B: An electroforming device 10 deposits electrodeposits 30 on the electrode line 19. When an electroformed element grows to a predetermined thickness, all of the electrode line 19,

the dummy lines 36, and the positioning lines 39 for machining are taken out by means of pulling out, pushing out, dissolving or the like.

Fig. 4C: Then, the electroformed element is subjected to finish machining with reference to positioning notches 41 which are formed after the positioning lines 39 for machining are taken out. Conventionally, in the finish machining the electroformed element was positioned with reference to the through hole 12 into which an optical fiber 32 is inserted. The through hole 12 was untouchable because the optical fiber 32 is to be inserted thereinto, so that it was difficult to accurately carry out the finish machining. The positioning notches 41, however, are touchable, so that it is possible to accurately carry out the finish machining. One example of the finish machining is to cut the electroformed element into a rectangle in cross section. As shown in Fig. 6D, a pair of ferrules 11a and 11b may be used as a plug and a socket. In this case, one ferrule 11a as the plug has the positioning notches 41, and the other ferrule 11b as the socket has a fitting recess 43 with fitting projections 44 integrally provided on the inner periphery thereof. According to this way, it is possible to accurately fit the two ferrules 11a and 11b.

EMBODIMENT OF FIGS. 5A TO 5C:

The manufacturing method of the ferrule according to the embodiment of Figs. 5A to 5C uses both of the positioning lines 38 for fit of the embodiment of Figs. 2A to 2F and the positioning lines 39 for machining of the embodiment of Figs. 5A to 5C.

Fig. 5A: Two dummy lines 36 are linearly aligned on each side of an electrode line 19. Outside of the electrode line 19 in a horizontal direction, positioning lines 38 for fit are disposed symmetrically with respect to the electrode line 19. The diameter of each positioning line 38 for fit is larger than the diameter of the electrode line 19 and dummy lines 36. Outside of the electrode

line 19 in a perpendicular direction, triangular positioning lines 39 for machining are disposed symmetrically with respect to the electrode line 19. The positioning lines 38 for fit and the positioning lines 39 for machining are insulated as with the dummy lines 36.

Fig. 5B: An electroforming device 10 deposits electrodeposits 30 on the electrode line 19. When an electroformed element grows to a predetermined thickness, all of the electrode line 19, the dummy lines 36, the positioning lines 38 for fit, and the positioning lines 39 for machining are taken out by means of pulling out, pushing out, dissolving or the like.

Fig. 5C: Then, the electroformed element is subjected to finish machining with reference to positioning notches 41 which are formed after the positioning lines 39 for machining are taken out. After the finish machining, as shown in Fig. 6B, pins for fit are fitted into two fitting holes 40 of a ferrule 11a to protrude therefrom. Since the pins are used for fitting the ferrule 11a in another ferrule 11b, it becomes easy to carry out the accurate positioning.

In the embodiment of Figs. 5A to 5C, as shown in Fig. 6A, the electrode line 19 may remain without being taken out. The materials and surface treatments of the electrode line 19, the dummy lines 35, the positioning lines 38 for fit, the positioning lines 39 for machining and the like are decided in consideration of ease in pulling out or pushing out. Unless the electrode line 19 is taken out, however, it is unnecessary to consider the ease of a method of taking out the electrode line 19, so that a range of materials which can be used as the electrode line 19 increases.

In the embodiments shown in Figs. 4 and 5, there is one electrode line 19, and the dummy lines 36 are disposed in the vicinity of the electrode line 19 to form the multiple-core type ferrule 11. However, when the through holes 12 are formed in one direction, and the outside shape of the ferrule 11 becomes flat after the machining as shown in Figs. 4C and 5C, the gap 31 shown in Figs. 11B and 11C is not left. Therefore, it is possible to manufacture the ferrule 11 by means of

properly combining the plurality of the electrode lines 19, the dummy lines 35, the positioning lines 38 for fit, and the positioning lines 39 for machining.

In the embodiments described above, the positioning lines 38 for fit are round in cross section, and the positioning lines 39 for machining are triangular in cross section. However, the shape of the positioning lines 38 and 39 are not limited to these shapes, and it is possible to properly choose the shape from among a rectangle, an ellipse, a star shape and the like, as long as they perform the necessary functions.

In the above embodiments, the electrode line 19, the dummy lines 36, the positioning lines 38 for fit, and the positioning lines 39 for machining are fixed on the electroforming device 10 with the use of the support jig 35, but the method of fixing them is not limited to the above embodiments, as long as they are fixed completely parallel with each other so as not to change their positions.